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Multilayered Materials

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Abstract

Recently, the research and development of advanced structural materials has emphasized two major areas: nanocrystals and composites. The goals of these two developments have considerable overlap even though the synthesis and processing approaches are quite different for each class of material. For example, the development of nanocrystals is aimed at significant improvements, through grain refinement, in mechanical strength, ductility, and toughness at room temperature as well as formability at high temperatures. The development of composites is also aimed primarily at improvements in room-temperature toughness and stiffness, and high-temperature strength. With respect to these developments, it is particularly interesting to note that some nanocomposites (or compositionally-modulated thin films), that is, composites containing components at the nanophase level of microstructure, have recently been produced by novel processing techniques. These nanocomposites exhibit extremely high strength and toughness values by combining the microstructural advantages of both nanocrystals and composites. These results are attributed to the fact that the microstructural uniformity and the size of defects in these materials are extremely small at the nanometer level.

Up to the present, a wide range of material combinations have been synthesized into nanolaminates. Free-standing plates and cylinders with thicknesses up to 0.15 mm, containing up to 50,000 individual layers, with areas of several hundred square centimeters have been fabricated. As an example, the results from a free standing, nanocrystalline, Cu/amorphous Cu_4Zr_3 laminate (~140 μm-thick) will be given in this presentation. The material possesses extremely high yield and tensile strengths while still retaining a reasonable tensile elongation. The strength properties of the laminate are compared with those of nanocrystalline Cu. It is proposed that the high strength properties of the nanolaminate result from the fact that the strong amorphous Cu_4Zr_3 layers are constrained, by interfacial bonding, to deform in conformity with the Cu layers. This allows the utilization of the high strength property of the amorphous phase to a high fracture strain.

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